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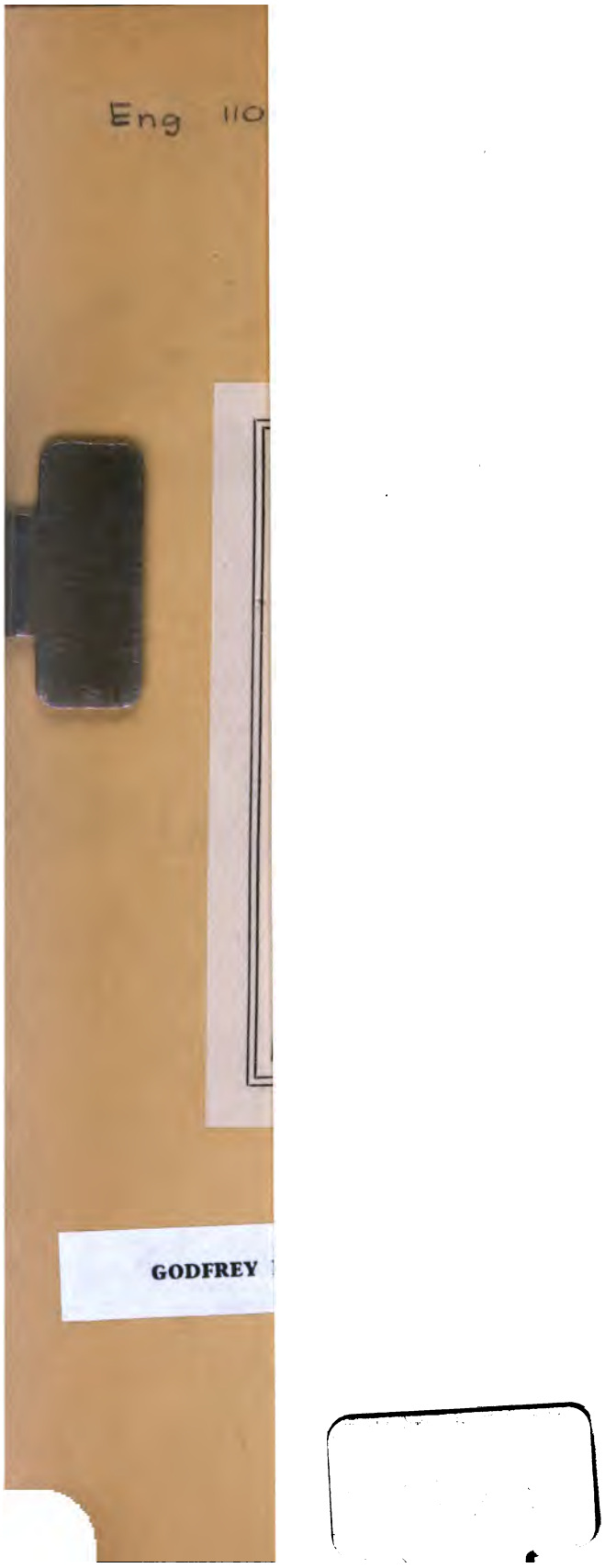
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Geo. R. Baldwin Esq
with the respects of
E. S. Chesbrough

REPORT

OF THE

COMMITTEE ON THE PETITION

OF

DAVID SEARS AND OTHERS,

IN RESPECT TO THE

DRAINAGE OF THE BACK BAY.

JUNE 4, 1850.

BOSTON:
1850.
J. H. EASTBURN, CITY PRINTER.

City Document.—No. 14.

REPORT

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COMMITTEE ON THE PETITION

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IN RESPECT TO THE

Page 10, for "patch," read part.
The letters A—A. on plan No. 2, indicate the *section of existing sewers.*

BOSTON:
1850.
J. H. EASTBURN, CITY PRINTER.

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CITY OF BOSTON.

In the Board of Mayor and Aldermen,
December 3, 1849.

ORDERED, That the report and plan, in relation to the Drainage of the Back Bay, be recommitted to the Committee on the same, with instructions to submit them to E. S. Chesbrough and William P. Parrott, Engineers, for their examination and opinion,—with such suggestions in relation to the whole matter, as they may deem expedient.

Passed.

Attest: S. F. MCCLEARY,
City Clerk.

In the Board of Mayor and Aldermen,

June 4th, 1850.

Laid on the table and ordered to be printed.

Attest: S. F. McCleary, *City Clerk.*

REPORT.

In the Board of Mayor and Aldermen,
Tuesday, June 4th, 1850.

The Committee to whom was referred the several communications of David Sears, John C. Warren, and others, in relation to the condition of the Flats lying west of Charles Street, called the Back Bay,—and who were instructed to consider and report the best mode of draining the southwesterly section of the City—beg leave to

REPORT:

That in pursuance of the order of the Board, of December 3d last, they submitted the plans and estimates, heretofore presented, to Messrs. Chesbrough and Parrott,—with instructions to go over the whole ground afresh and report in detail.

The accompanying documents are the result of their labors; and we are happy to say that they bear marks of great care and deliberation, and are so full and explicit as to need little elucidation from us.

It will be perceived that more thorough and careful surveys have shown the practicability of adopting a self acting system of drainage, without any resort to flush-

ing, or other mechanical contrivances. And, as all expedients of this sort are regarded by experienced men as highly objectionable, and to be avoided when possible, the present engineers have not hesitated to take advantage of this circumstance, by making their levels conformable to the requirements of such a system. Instead, therefore, of draining the whole territory through one main sewer having its outlet near the Western Avenue, they now propose to drain the district lying south of the Worcester Railroad Bridge, through Dover Street into the Bay, near the South Boston Bridge;—and that north of it, through the Mill Dam into Charles River. In the expediency of these alterations, it is satisfactory to know that Mr. Lincoln concurs.

The plans, as now presented, do not claim to be perfect; but they are considered the best that the present condition of things will admit of. The simple fact, shown by the surveys, that the whole descent which can be given to the main culvert, from Camden Street to the outlet, one foot below mean low water mark at South Boston Bridge,—a distance of over two thousand yards,—is only seven feet, proves, at once, the impossibility of obtaining a perfect drainage,—except at the cost of raising up streets already thickly covered with houses, and, at the same time, discloses the serious difficulties which have been encountered in securing even a good one. Unfortunately, the question has been,—not what is desirable, but what, under existing circumstances, is possible. The engineers, however, seem to have disposed of it in a manner highly creditable to their skill and ingenuity. They have conformed to the levels already established; and, notwithstanding, have succeeded in laying down a series of sewers that will be self acting, effective and undoubtedly sufficient

for the entire house and surface drainage. Whatever inconveniences might be apprehended from the sudden flowing in of back water, have been provided for by flaps at the outlets, and a waste wier on the empty basin.

The Report and Appendix depict, with great power and truth, the evils which inevitably result from permitting a low level to exist in a crowded and populous city; and, it is to be hoped that the facts and suggestions which they offer, will command the serious attention of those who may hereafter have the important subject of drainage under their control. Undoubtedly, the difficulties, now experienced in the southern section of the City, are mainly due to want of knowledge, or forethought. And, certainly, if, in any case, responsibility should be felt, or neglect of duty visited with severe rebuke, it is where, as here, the interests to be affected are the health and comfort of a large population for an indefinite period of time. With our present experience, it may be an act of supererogation to remind this Board of its obligations, in respect to the grade of territory belonging to the City; but it is certainly not inappropriate, to draw its consideration to the absolute necessity of some additional legislative enactments, for compelling private individuals to bring their lands and buildings to a proper height for drainage, before they are sold and occupied. As the law now stands, any proprietor of land may lay out streets at such levels as he shall deem to be for his immediate interest, without municipal interference; and when they have been covered with houses, and a large population are suffering the deplorable consequences of defective sewerage, the Board of Health is called upon to accept them, and assume the responsibility of applying

a remedy. But the case is hopeless,—the nuisance cannot be abated; and the only resource, too extreme to be carried out, is to shut them up entirely. Certainly, no private individual has any more right to do that which will inevitably inflict an incurable nuisance upon a future generation, than he has to commit a present wrong upon his neighbor's person or property; and if the law takes cognizance of the one case, it ought to do so in the other.

The question of the expediency of providing a proper system of drainage for the southwestern section of the City has already been decided by this Board; and, although it is to be regretted that so large an expenditure is called for at this time, your Committee are satisfied that the exigencies of the case are such, as not to allow of any hesitation in commencing the undertaking. The health of a large population and the value of the City lands, are too important interests to be sacrificed to any feeling of mere economy; and they are both involved in this matter of drainage.

At this very moment, some of the principal sewers in the vicinity of Dover Street are obstructed by the earth which has been thrown into the empty basin, under the direction of the Water Power Company, on the westerly side of the Tremont Road, in order to bring their property into use, and their contents are fast creating a grievous nuisance by permeating through it.

We recommend that the report and accompanying documents be printed and published;—and, when sufficient time shall have elapsed to read and understand them, we propose to submit certain resolutions for the action of the Board, founded upon the following propositions.

1st. That the Board establish a grade for all unoc-

cupied land belonging to the City, which shall not be lower than the coping of the dry dock at Charlestown, or extreme high water mark.

2d. That legislative power shall be applied for,—sufficient to compel individual owners of land to grade their property to said height, before they lay it out into lots and streets.

3d. That the plans and estimates, now presented by Messrs. Chesbrough and Parrott, be adopted for the drainage of the southwestern section of the City; and that this Committee be fully empowered to lay down, the present season, the main culvert and connecting drains, as therein indicated, through Dover Street and that portion of Tremont Street which lies between the Railroad bridge and Waltham Street.

In behalf of the Committee.

HENRY B. ROGERS, *Chairman.*

REPORT.

To ALDERMAN ROGERS, *Chairman of the Committee on the Memorial of David Sears and others, relative to the Drainage of the Back Bay.*

SIR:

In obedience to the order, transmitted to us by you, the undersigned have given the subject much and careful attention, during the interval left by other engagements which they were under previous obligation to meet. They have been much longer than they expected in preparing this report; but the importance of the subject, as well as its difficulty, has very much increased, as they have investigated it; and they have felt unwilling to propose any measure without weighing well all the considerations that might be urged for or against it.

They have consulted with Mr. Lincoln, and after obtaining from him such explanations as were necessary to a proper understanding of his reasons for recommending the plan proposed in his report, they are

gratified in being able to state, that "while he, of course, prefers his own plan, with, as he suggests, the alteration of entering the lateral drains on the side in lieu of the top of the main sewer in Tremont street, he yet *assents* to the modifications we have herein proposed; provided the City deems it advisable to make the requisite additional expenditure of money."

The district to be ultimately drained, is bounded, on the south, by the line between Roxbury and Boston; on the south east and east, by Suffolk, Castle, Washington, Pleasant and Charles streets; on the north, by Beacon street; and on the west and northwest, by the Roxbury line. It contains about 334 acres; and is either a part of the Empty Basin, or naturally drains into it.

A part (147 acres) is at present covered by the part of the Empty Basin, which lies within the limits of the city, and is not occupied by houses or graded streets. The remainder is occupied by about 1000 houses and 33 streets, south of the Worcester Railroad; and about 850 houses and 20 streets, north of the Worcester Railroad. This particular division is made with reference to plans hereinafter proposed.

South of the Worcester Railroad, 340 houses, of all classes, stand on streets which have been graded to a lower level than high water. North of the Worcester Railroad, 245 houses on 20 streets are in the same situation in regard to high water. (See A, of Appendix.)

Over nearly every part of this district the tide would ebb and flow daily, were it not for the dam which has been constructed by the Boston Water Power Company. (See contour lines in blue on the accompanying plan of this district.) The construction of this dam

has afforded an opportunity for adopting a system of low graded streets and short cheap drains, which has been extensively taken advantage of; but it has, for this very reason, led to serious evils that have already been described in your report of July 2d, 1849. From that report we will make the following extracts, as expressing our own views.

"In fact the Back Bay at this hour is nothing less than a great cesspool, into which is daily deposited all the filth of a large and constantly increasing population. And it is a cesspool of the worst kind, contrived, as it were, for the purpose of contamination and not of relief; for it is an open one, and, therefore, exposed continually to the action of the sun and weather, and every west wind sends its pestilential exhalations across the entire city."

* * * * * *

" * * * The stagnant state of the waters which half cover this basin, and the constant accumulation of various foreign substances, around the mouths of the sewers that open upon it, subject each inhabitant, who is obliged to drain into it, to a special inconvenience and injury from the backing up of the contents of his drain, and the passage of offensive effluvia into his premises." * * * * "In consequence, an increased body of filth from the streets and houses of this large territory, including the contents of privies and water closets, daily percolate through several hundred imperfect and ill constructed drains, and is thrown out upon the margin of the basin, sometimes under the surface of the water, and sometimes above it."

* * * * * *

"Every accession of matter forms a nucleus, around which other substances gather; thus impeding the force

of the current which remains, and serving to bring the whole mass nearer and nearer to the surface of the water. A greenish scum, many yards wide, stretches along the shores of the basin as far as the Western Avenue; whilst the surface of the water beyond is seen bubbling, like a cauldron, with the noxious gases that are exploding from the corrupting mass below. It is needless to go into an argument to show the evils which spring from such a state of things as this." (See also A. A. of Appendix.)

Had not the error of permitting the Mill Dam to be built, been made in the first instance, the equally great, if not far greater, error, of permitting the streets of this district to be graded below high water, with the consequent drainage into the Empty Basin, could not have been committed. As it is, landholders, in this district, have a great apparent advantage over all other owners of land, in districts on the same level, in consequence of having so much less expense to incur in grading their streets and filling up their lots. But this advantage is only an apparent one; for there is much reason to believe that, if all the streets had been graded to a height a little above the level of high water mark, and the drains had not been suffered to fall into the Empty Basin, real estate, in the improved parts of this district, would have been more than sufficiently high above its present value to have made up for the difference of the first cost.

It appears that the present system of drainage was adopted, on the supposition that the Empty Basin was to continue to be used, as it now is, forever. The City is secured in the right to drain into the Basin forever, by an agreement with the Water Power Company. (See Suffolk Deeds, Book 315, folio 279.) But the

Water Power Company are not liable for any accidental breach of their dam, or any unforseen or unavoidable occurrence, which might fill the Empty Basin to the level of high water and do a vast amount of damage.

The great and increasing evils, resulting from the present system of drainage, will be admitted by all who examine the subject; but that the system has grown out of the practice of grading the streets too low, and cannot be thoroughly remedied without a change in this respect, will probably be questioned by many. We hold this to be the case, however, and shall give a few reasons for making the statement.

All will admit the impossibility of having an efficient system of sewers without some inclination to them, so that their contents will drain off. But many of the houses in this district have been so constructed, that their basements and back yards are only a very little above mean low tide. (See cross section of Dover street, plan No. 2.) Consequently, the sewers, in order to drain them at all, must be very low down, and act as drains only three or four hours out of the twenty-four. Even then their declivity must be so small, as to give but little velocity to the current through them. At other times, they will be but extended cesspools, and, consequently, generators of noxious and pestilential effluvia.

Should the whole of the Empty Basin ever be improved, (an event by no means improbable,) the present or any other system of drainage, dependent upon low graded streets, would be found exceedingly inconvenient, if not totally inadmissible, and for the reasons already mentioned. The surface drainage would then be very troublesome to manage; and, in case of heavy rains, during high tides, could not be disposed of with-

out inundating the cellars and streets of the lowest portions of the district; and then, most probably, it would be mingled with the contents of the sewers.

To remedy the evils thus specified, and afford a permanent and safe system of drainage, the following recommendations are made.

1st. That as adequate a system of sewers as possible be provided for both house and surface drainage.

2nd. That these sewers, for about 150 acres of the eastern portion of this district, south of the Worcester Railroad, be made to empty into the South bay, at South Boston bridge; and that the remainder be discharged into Charles river.

3rd. That the whole system should be, as far as possible, within the limits of the City of Boston, and subject to its municipal jurisdiction.

4th. That no street be accepted by the City, unless it be graded fifteen feet above mean low tide.

5th. That the low portions of the district, which are already improved, be protected, as far as possible, from inundation, by such temporary expedients as are practicable, until a judicious plan of raising them to the height proposed, can be adopted and carried out.

In order to carry out the first recommendation, it is proposed to lay sewers of sufficient capacity to carry off, not only the ordinary house drainage, but that which will be caused by rains upon the surface. The former may be computed with some degree of accuracy, and has been estimated at .006 cubic feet, per acre, per second. This is based upon the supposition that the number of inhabitants, per acre, will be about one hundred and twenty-eight, and that the average consumption of water by each inhabitant, will be thirty wine gallons per day. As the ebb and flow of the tide will

obstruct the drainage from the sewers, more or less, nearly all the time, it would be safer to estimate the ordinary sewerage from houses, manufacturing establishments, &c. at .018 cubic feet the acre per second.

The necessity of providing for *surface* drainage, in undulating districts situated comparatively near the outfalls of the sewers, may be doubted; but in flat districts of any extent, experience, in all ages and climes, shows it to be necessary for health, comfort, and safety. In the present case, the surface drainage has been permitted to remain on the open lots, or to fall into the Empty Basin. But as the improvements of this district become extended, the inconvenience of such a state of things will become more and more apparent. It would not be wise therefore to begin, or continue, a system which does not provide for the ultimate drainage of the surface of the whole district. It is not proposed, however,—neither would it be judicious, to provide for the whole of it now.

The quantity of surface drainage, per acre, per second, must of course depend upon the quantity of rain in a given time. This is known to be very variable. Something however must be assumed, and it is proposed for a basis of estimate, to adopt *one* inch per hour. Twice this quantity has been known to fall here and at Cambridge; but most rains afford considerably less. (See statement B, in Appendix.) One inch per hour is the quantity proposed to be provided for, by an eminent Engineer to the English Metropolitan Commission, although the mean annual quantity in England is less than ours. They have there, however, extraordinary rains, which furnish *two* inches an hour. (See statement C, Appendix.)

To carry out the second recommendation, it is propos-

ed to lay a main sewer, of the following forms and interior dimensions, from the Roxbury line, along Tremont Street, to Dover Street, and thence along Dover Street, to an outlet belonging to the City, in the western abutment of the South Boston Bridge. That is to say, from South Boston Bridge to Tremont Street, circular, 6 ft. in diameter; from Dover Street to Brookline Street, egg-shaped, 5 ft. high and 3 ft. 4 in. wide; from Brookline Street to Concord Street, egg-shaped, 4 ft. high and 2 ft. 8 in. wide; and from Concord Street to the Roxbury line, egg-shaped, 3 ft. 8 in. high and 2 ft. 5 in. wide. As far as Concord Street, it is proposed to make the sewer 8 inches thick, and in two concentric rings or shells, each half a brick thick. From Concord Street to the Roxbury line, it is thought half this thickness would be sufficient.

In order to accommodate the lateral drains already laid, it is proposed to give the bottom of this main sewer an inclination of 1.00 foot between the South Boston Bridge and Tremont Street, beginning at the former place, 1.00 foot below the level of ordinary low water, or 1.10 feet above extreme Spring low water; and from Dover Street to the Roxbury line, 6.30 feet, or 1 5-8 inches per 100 feet. Had no improvements been made in this district, we should recommend the level of ordinary low water as the starting point, and an inclination of 2.00 feet between the South Boston Bridge and Tremont Street. This would raise all the sewers along Tremont Street two feet higher, which would be of great importance to the drainage of that part of the district. But it is not to be expected that the errors which have heretofore been committed will be corrected in a year or ten years, if ever; and, therefore, the system now proposed has been

devised to meet the actual state of things, and not that which should have existed.

From the Worcester Railroad, southwardly, a smaller main, egg-shaped, three feet eight inches high, and two feet five inches wide, should be laid along Tremont or Village street to Dover street. The inclination proposed for this sewer is 1.4 feet, or about 1¼ in per hundred feet, which will intersect all the present lateral drains sufficiently low down to prevent much expense in altering them.

From the Worcester Railroad, northwardly, it is proposed to lay a wooden main, along the line between the Water Power Company and the City, to Beacon street, and thence into Charles River, by such an outlet as the City may be able to control. Wood is proposed for this sewer (with the exception of the part passing through the Mill Dam, which is to be of brick,) because its location cannot be considered as permanent. No street has ever been laid out on this line; and it is not certain that one ever will be. The sewer, when permanently located, should be in the line of some street.

The inclination of this sewer is not uniform throughout. We propose to lay the part from the Worcester Railroad to Boylston street, in such a manner as to receive all the drains which are now discharging into the Empty Basin,—and the part from Boylston street, through the Mill Dam, on such inclination as the limits of the tide will allow. As most of the drains on this section are small private drains, and will probably be rebuilt, we consider it better to make this arrangement than to alter them at this time, which it would be necessary to do, if the sewer should be laid at a true inclination throughout.

The remaining portion of this district, unprovided for

by the sewers already mentioned, being mostly situated in the unimproved part of the Empty Basin, may need no further provision for a number of years. Whenever it shall need it, the streets will probably be permanently laid out, and their drainage may then be arranged much better than it could be now; it being understood, that the large mains through Dover street and the Mill Dam, are to be laid down, at first, of sufficient sizes to receive all the branches that should ever drain into the South Bay and Charles River, from that portion of the City included in the district already described.

The third recommendation does not require comment; it being always adopted as a settled principle, wherever it can be carried out. It may be necessary to depart from it, however, in providing for that portion of this district which is situated south of the Worcester Railroad, and the boundary between Roxbury and Boston, should it be built upon. This portion ought to drain directly across the Empty Basin and the Mill Dam, passing through a portion of Roxbury.

The fourth recommendation, if carried out, would prevent an increase of the evils that have resulted from the neglect of such a rule heretofore; and perhaps render it possible to remove those that already exist. This, however, must, be a work of time; for when streets have been accepted, paved, and built upon, it will be very difficult and expensive to alter them to what they should have been.

The undersigned have adapted the grades of the sewers to the present state of things as far as possible; at the same time, they would be capable, without alteration, of accommodating a better state of things. For reasons already given, however, they firmly believe that, in the end, health, comfort, and economy, would be

greatly promoted by raising the grades of the streets in this district to a level above that of high tide; and, in relation to those which are not already built upon, they strongly recommend that, hereafter, the grade of no street be established at a lower level than the coping of the dry dock at Charlestown, and that all buildings hereafter erected upon this district should be so placed as to conform to such established grade.

They have made an estimate of the cost of grading such streets, which will be found in the appendix. (See C. C.)

The fifth recommendation is important, in order to avoid violating the maxim, "that great caution is necessary in recommending alterations, lest while seeking to afford a remedy for the public, great injustice may be done to individuals."

The present interests of individual landholders are always an obstacle to carrying out any proposed public improvement. In this instance, there is a large private interest opposed to the alteration required by the most efficient system of drainage. The number of houses which would be affected by the proposed change is about fifteen hundred and seventy.

In order to protect them from inundation by salt water, it will be necessary to keep the tide from flowing into the sewers by means of flaps. This mode is objectionable, because it is liable to get out of order, and because the flaps themselves are an obstruction; but we do not see how they can be dispensed with.

In order to guard the basements and back yards of these houses from inundation by heavy rains, during high tides, it will be necessary to have one or more waste weirs, discharging from the main on Tremont street into the Empty Basin, and placed at such a level

as to act only when the sewers are filled to overflowing, either from heavy rains, or from the flaps getting out of order and letting in the tide.

Should the Empty Basin ever become covered with houses and streets, this plan of wasting surplus water into it, could not be continued. In that case, we see no practical remedy except pumping, for preventing the inundation of the basements and back yards of houses in the lowest parts of the district, should heavy rains occur during high tide; unless, indeed, the streets are raised high enough above the tide to turn the water in that direction, either by surface or underground drainage.

For the purpose of informing ourselves thoroughly with regard to the subject of drainage, we have obtained from Charles B. Wells, Esq., Superintendent of Sewers for this City, and from other experienced persons, much valuable information about home experience; and have examined the massive English Parliamentary Reports of the "Commissioners of Inquiry into the state of large towns and populous districts," and the "Metropolitan Sanitary Commission," which was confined, more particularly, to London, and goes very extensively into this subject.

In these reports, we find a very large amount of information, bearing directly upon points similar to those now under consideration. They give the experience of centuries, and of many distinguished individuals.

And although there is much diversity of opinion upon many practical matters connected with the subject of drainage, yet, upon the important points alluded to below, there seems to be a near approach to unanimity. These, so far as they are of consequence in making this report, are,

1st. That the circular, or elliptical form of sewer is the best.

2d. That any increase of size in a sewer beyond what is absolutely necessary for the drainage of the district, is not only a useless expense, but a positive evil.

3d. That in ordinary sewers, an inclination of 2½ inches per 100 feet is necessary to preserve them from deposits.

4th. That the intermitting system of drainage, caused by the entrance of tide water into the sewers, or, what amounts to the same thing, the closing of flaps to prevent the entrance of tide, although unavoidable in some low districts, is decidedly objectionable.

5th. That any system of drainage, to be perfect and safe at all times, should be self acting; that is, unincumbered with flaps, valves, flushing apparatus, or machinery of any kind.

6th. That square junctions of lateral or branch sewers with mains should be avoided.

7th. That cesspools of all kinds, whether in the form of sewers, privies, or other reservoirs of filth, are objectionable, though, sometimes, very difficult, if not impossible to avoid.

8th. That in order to prevent serious errors in the construction of new sewers, accurate surveys of the old ones, and of the whole city, or district, should be recorded in some central office; so that any one wishing to build or lay a house drain, might readily ascertain the exact position of any sewer, with its level at any point above some common base; and the level of any part of any street above the same base. (The importance of this rule has already been recognized in Boston and partially carried into effect.)

The truth of the first of these statements is perfectly

clear to all who have paid the least attention to hydraulics; it being well known, that the least perimeter in contact with water, the section of any conduit has, in proportion to its area, the more capable it is of discharging its contents. Hence, for open conduits, the semi-circular form gives the greatest discharge, and for closed ones, entirely filled, the full circle is the best form; in other words, the common cylindrical pipe, which is the simplest and strongest form of conduit of equal size, is also the most capable of discharging water. A proper application of these principles to sewers filled only occasionally, and ordinarily having but a small quantity of liquid to discharge, would lead to the adoption of the egg-shape, with the point downwards; and actual experience has fully proved their correctness. Hence, our preference for the circular form between South Boston Bridge and Tremont street, and for the elliptical and egg-shaped forms in Tremont street; for, throughout the whole length of Dover street, the sewer will be more than half filled, most of the time, while, in the larger part of Tremont street, this will not be the case.

Other considerations have also had influence in causing this preference. An oval form, of the same capacity as the circular, could not be sufficiently protected in a part of Dover street, without raising the grade of the street so as to do serious damage to the houses on each side. In some parts of Tremont street, the circular form of equal capacity would not be so convenient, for the purpose of cleansing, as the oval. Were it not for the tide, which will cause the water to be stagnant in these sewers a part of the time, there would probably be no need of cleansing them at all; as the ordinary

house drainage would be sufficient to keep up a current that would prevent deposits. (See D, of Appendix.)

The second statement is very evident from what has already been said about the forms of sewers; the semi-circular bottom, if covered, being the best, and the wide flat bottom the worst. Of course, if a circular sewer is made so large, that the sewage will only cover an inch or two of its bottom, while spreading out a foot or more in width, it approaches, in practice, the flat bottom. (See D, of Appendix.)

It is often found expedient to make sewers larger than the drainage requires, in order that they may be easily entered, and cleaned; but this is not very objectionable, when merely of sufficient size for entering, and the egg-shaped form is given them.

In determining the sizes of the sewers recommended here, the rule relative to iron pipes for conveying water has been followed. Experience on the Croton and on the Boston Water Works, shows that well constructed brick conduits present as little resistance to the flow of water, as new cast iron pipes of equal size.

There is a practical difficulty in applying this rule in the present case; because the rise and fall of the tide would affect materially the inclination of the surface of the water in the sewer, or what is more commonly called the head. The inclination of the bottom of the sewer is, as before stated, only one foot from one end of Dover street to the other, but we assume that the actual head of water that may be relied upon, in cases of emergency, may be called three feet for the same distance. This would give a discharge of 141.2 cubic feet per second, according to the common formula of Prony.

The third statement is the result of much observation. (See E, of Appendix.) It is much to be regretted

that any part of the sewers recommended in this case should have a less inclination than is above indicated, but the nature of the district does not admit of more, without heavy additional cost in altering the present cross-drains, and raising the grades of streets. We believe, however, that the inclination proposed will prevent serious obstructions.

The fourth statement is verified by home experience; it being well-known that sewers or drains in which the tide backs up, often emit noxious effluvia, against the admission of which, each house must have its traps. These sometimes fail, or get out of order. Ventilation, by means of chimnies and water spouts connecting with the sewers, may do much to remedy this evil; but it would be prevented altogether by a sufficient current, constantly kept up, so as to prevent any stagnation or deposit in the sewers. This could only be done here, by resorting to pumping; a method we are not prepared to recommend, though it is advocated very strongly by Henry Austin, Esq. and other civil engineers, for the low districts of London. (See F, of Appendix.)

The fifth statement must be obvious to all who know how liable are mechanical contrivances, not constantly watched, to get out of order and become troublesome. For this reason, they are not recommended here, any further than is absolutely necessary; which is the case with the flaps at the outlets of the sewers, and the traps for the cellar drains, or hollow logs, for each house in the lower parts of the district. (See F F, Appendix.)

The sixth statement is evident from the well known fact, that, in conduits, all departures from a straight line are sources of retardation to the flow of water through them, in proportion to their abruptness. But

owing to the greater mechanical difficulty of making curved junctions than straight ones, the latter have been very generally adopted for sewers, although they often, if not always, cause deposits and obstructions which have to be removed, either by hand or by flushing.

The seventh statement is corroborative of the opinions of the Committee, as expressed in their report of July 2d, 1849, and already quoted. All stagnant bodies of water, filled with decomposing animal or vegetable matter, must generate noxious gases; and these gases will find an outlet somewhere, even if generated in covered cesspools, with every contrivance for preventing their escape, compatible with any kind of drainage through them. If, by means of traps and valves, these gases are prevented from escaping anywhere, except at the outfalls of the sewers, they prove a serious nuisance, and sometimes lead to strong remonstrances, and to litigation.

The eighth statement must carry the conviction of its truth and importance to the mind of every one, who is at all acquainted with the subject, or who will take the trouble to investigate it. Instances are mentioned, in the English reports, which show that serious losses and inconvenience in the laying of sewers are liable to occur, even with the most careful Engineers, when no general system has been adopted, and access cannot be had to accurate recorded plans and levels of the district in which it is proposed to build. (See G, Appendix.)

Much is said in the English Reports about the value of sewerage as a manure; but as a general thing, cities and large towns do not appear able to make it a source of much revenue. All seem to agree that it ought to be valuable, and some appear to be sanguine that it

soon will be considered of great importance. (See H, Appendix.)

In consequence of the peculiar position of Edinburgh, the sewerage of that city is conveyed through pipes, without the aid of mechanical power, and made very valuable by irrigating meadow lands. But even this is at the sacrifice of the comfort of those who live in the immediate vicinity; the stench arising from it being considered a great nuisance.

As to the value of the sewerage, as a manure, in this vicinity, we have little means of judging. Our opinion is, that at present, at least, it is not worth transporting into the country. How soon it may be, we shall not attempt to predict. Whenever that time shall come, there will be no difficulty in constructing such reservoirs as may be necessary; and it is probable that experience, in the meantime, will show better how and where to construct them, than can be done now.

With regard to the deposits in the harbor from sewers, while we believe that such deposits are taking place on some of the flats, and in the slips along the lines of the wharves, near the outlets of the sewers, we also believe that the cheapest way to remove the sewerage, is to let it be deposited; and, whenever the slips get so filled up as to become a nuisance, to have the deposit dredged out, and carried away in scows.

DETAILS OF CONSTRUCTION.

In making the estimates, the work has been divided into two sections.

The first section includes the whole of the work between Roxbury line and South Boston Bridge, and the sewer between Dover Street and the Worcester Railroad.

The second includes the part between the Worcester Railroad and the outlet at the Mill Dam.

FIRST SECTION.

The estimates upon the first section are for permanent sewers, in masonry throughout; as the location and grade of the streets and the construction of the lateral sewers, previously laid, render it improbable that any change affecting this system, will ever be made.

Brick Work.—No. 1.

The estimate for the brick work is made upon the sections of sewers accompanying this report, with the length of each section marked upon it. A due allowance has been made for the extra thickness which may be required in some parts of the length.

This estimate of brick work, also, includes the alteration of such sewers, six in number, as may be too low to come into the main, and, also, the joining of the whole of the lateral sewers, seventeen in number, by circular connections.

There is also included, the quantity sufficient to construct thirty-two man holes, and the small sewer, north from Dover street.

Stone Masonry.—No. 2.

Stone is used for the purpose of guarding the outlet and constructing the flood gates and waste weir, to prevent the overflow of the tide and rains. This estimate has been made with a view to the most rigid economy, and makes no provision for any thing not required to make the work strong and durable.

Excavation.—No. 3.

The prices and quantities have been carefully cast, and are taken from experience in similar work, done within the last two years.

No deduction has been made for the earth left; should this be taken away, without cost to this account, it will reduce the estimate by $748.44.

Wood Work.—No. 4.

This includes the necessary cost of timber and plank for curbing the trenches, and is intended to represent the actual cost, after disposing of the materials remaining, when the work is completed. It also contains the estimated cost of the flood gates, including materials and labor.

Incidental Expenses.—No. 5.

This item is indefinite from the nature of the case. It is made with a view to cover the expense of the items included in it, so far as we can forsee them; it may be exceeded in consequence of unforseen difficulties, which are provided for in the contingent account.

Paving.—No. 6.

This account is for the paving of Dover street, from

Tremont street to Harrison avenue, east side, over the line of excavation which is made to lay down the sewer.

No estimate has been made for connections of sewers, other than for those which now discharge into the Back Bay.

SECOND SECTION.

The estimates upon the second section are not made for a sewer of so permanent a character, as that upon the first section.

The main sewer is to be built of wood, instead of brick, as far as the Mill Dam, near the proposed outlet; but the estimate provides for constructing the portion through the Mill Dam, in a permanent manner.

ITEM, No. 1.

This includes all the materials and labor required to construct a timber drain, from the Worcester Railroad to the Mill Dam, 3,500 feet.

This sewer is to be 4 feet by 5 feet, or with an inside area of 20 square feet. The reasons we have for recommending this size, are that it may be more readily entered and cleaned, when required; and, also, that we may obtain a reservoir for the sewerage, when the tide is in and the sewer cannot discharge outside of the Mill Dam.

We think these considerations outweigh the difference in cost between this and one of 3 by 3 feet, which is estimated at $3,000 less; the difference being, mainly, in the cost of the timber. This estimate includes, also, the timber and plank for curbing, and the materials and labor for the flood gates.

ITEM, No. 2.

Excavation through the Mill Dam will be deep and difficult, and a higher price is estimated than on the first section, for this reason.

ITEM, No. 3.

This includes the brick work for the part of the sewer running across the Mill Dam, and includes the manholes and curbs.

ITEM, No. 4.

Includes the stone work required for the chambers of the flood gates. The arrangement of the gates is different from that of the first section; as one gate will be placed on the outside of the dam and the other on the inside, in a separate chamber. This last chamber is to be so arranged as to serve for the waste weir, in case of heavy rains or accident to the flood gates.

ITEM, No. 5.

The same remarks, with regard to incidental expenses, which are made on section first, will apply to this section also.

No estimate is made for altering any of the lateral drains, or curving their outlets, as they are, mostly, temporary private drains.

ESTIMATED COST OF CONSTRUCTION FOR THE FIRST SECTION.

ITEM, No. 1.—BRICK WORK.

1,509,000 bricks, including cement, labor and laying, . . .	$14.00	$21,126.00

ITEM, No. 2.—STONE MASONRY.

Stone work for gate chamber at the outlet of sewer, 97 cu. yards,	*a* $10.00	$ 970.00
For waste weir, 108 cu. yds.	*a* 6.00	648.00
For 32 curbs to manholes,	*a* 8.00	256.00
Rough stone for walls, 50 cu. yds.	*a* 4.00	200.00
		$2,074.00

ITEM, No. 3.

Excavation, 10 ft. deep, 8,889 cu. yds.	*a* 50c.	$4,444.50
" under 10 ft. deep, 6,277 "	*a* 40c.	2,510.80
Refilling and ramming, 9,383 "	*a* 12c.	1,125.96
Removing, 4,158 "	*a* 18c.	748.44
Excavation to alter lateral sewers, including refilling and ramming, 1,782 cu. yards,	*a* 62c.	1,104.84
		$9,934.54

ITEM, No. 4.

Timber and plank for curbing, 20 M. *a* $12,	$240.00
Fitting same,	50.00
Flood gates, including materials and labor, two sets, *a* $187.50,	375.00
	$ 665.00

ITEM, No. 5.

Incidental expenses, pumping,	$ 450.00
For arranging outlet to waste weir,	250.00
For foundation, piling, &c.,	500.00
For coffer dam and removing old wall,	250.00
	$1,450.00

ITEM, No. 6.

Paving, 2,000 square yards,	*a* 35c.	$ 700.00

RECAPITULATION OF SECTION No. 1.

Item, No. 1, ...	$21,126.00
" " 2, ...	2,074.00
" " 3, ...	9,934.54
" " 4, ...	665.00
" " 5, ...	1,450.00
" " 6, ...	700.00
	$35,949.54
Contingent account, . . .	3,594.95
	$39,544.49

ESTIMATED COST OF CONSTRUCTION FOR THE SECOND SECTION.

ITEM, No. 1.

For timber for drain, 3,500 feet in length, 400 M, at $16, ...	$ 6,400.00
Carpenters' work and fastening, . .	1,400.00
Labor in preparing bed and laying sewer, .	1,322.00
Earth work for covering sewer, 7000 yards, *a* 40c., ...	2,800.00
	$11,922.00
Timber and plank for curbing, including setting, ...	60.00
For flood gates, including labor and materials, 2 sets, ...	375.00
	$12,357.00

ITEM, No. 2.

Excavation through Mill Dam, 1,800 cu. yards,			
		a 75c.	$1,350.00
1,400 cu. yds. refilling and ramming,		*a* $12,	168.00
400 " removing,		*a* 18c.	72.00
			$ 1,590.00

ITEM, No. 3.

Brick work, 300 feet, 1st class, 92,400 bricks,			
		a $14,	$1,377.60
Manholes, 3, .	6,480 bricks,	*a* 14,	95,76
Curbs and covers, 3, . . .		*a* 8,	24.00
			$ 1,497.36

ITEM, No. 4.

Stone masonry, cut stone, 97 cu. yards,			
		a $10,	$ 970.00
For waste weir,	52 "	*a* 6,	312.00
Rough stone,	50 "	*a* 4,	200.00
			$1,482.00

ITEM, No. 5.

Incidental Expenses:	
Taking up wall, ...	$ 84.00
Excluding tide, ...	320.00
Pumping, ...	175.00
Piling for foundations, ...	320.00
	$ 899.00

RECAPITULATION OF SECTION No. 2.

Item, No. 1,	$12,357.00
" " 2,	1,590.00
" " 3,	1,497.36
" " 4,	1,482.00
" " 5,	899.00
	17,825.36
Contingent,	1,782.53
	$19,607.89

TOTAL RECAPITULATION.

Section first,	$39,544.49
Section second,	19,607.89
Total,	$59,152.38

In conclusion, we would state, that the differences between Mr. Lincoln's plan and estimate and our own, may be referred to the fact that he did not think it necessary to provide for any surface drainage of importance, believing that, for the present, it might be allowed to run into the Back Bay, and that he intended to cleanse the sewers by periodical flushing. Hence the uniform size of his sewer throughout; its small inclination and arrangement of valves. We prefer to recommend, that provision should be made for the whole ultimate surface drainage of that portion of the district, whose outlet it is proposed to make at South Boston Bridge, so far, at least, as the sewer in Dover street is concerned; and we would avoid the necessity of periodical flushing as a permanency, especially with water directly from the Cochituate pipes. Hence the

variable size and inclination of the sewers; the outlet at South Boston Bridge; the absence of valves and permanent flushing apparatus; and the increased estimated cost.

The accompanying plans illustrate this report, and, it is believed, sufficiently explain themselves.

All which is respectfully submitted.

E. S. CHESBROUGH,
WM. P. PARROTT.

Boston, June 3, 1850.

APPENDIX.

A.

RELATIVE POSITION TO TIDE WATER, OF STREETS AND HOUSES, ADJOINING THE BACK BAY.

Names of Streets.	Contour line, or Curve of 15 feet above mean low water.	Houses below 15 feet curve.				Contour line, or Curve of 12 feet above mean low water.	Houses below 12 foot curve.			
		Brick, 1st quality.	Brick, 2d quality.	Wooden Houses.	Public Buildings.		Brick, 1st quality.	Brick, 2d quality.	Wooden Houses.	Public Buildings.
Arnold,	350 feet from W. line of Washington st.			5						
Lenox,	170 feet from W. line of Suffolk, towards Tremont,									
Camden,	Intersection of Tremont street, and 50 feet from west line of Suffolk street,									
Northampton,	15 feet from west line of Suffolk street,			2						
Chester,	50 " " " " "									
Springfield,	At intersection of Suffolk st., 353 feet above,									
Worcester,	382 feet from east line of Tremont,									
Concord,	360 " " "					35 feet from east line of Tremont, and at intersection of Tremont,				
Rutland,	275 " " "					100 feet from east line of Tremont street,				
Newton,	Intersection of Newland street,		2	1		185 " " " " " "				
Pembroke,	Intersection of Suffolk street,			13		155 " " " " and intersection of do.				
Brookline,	" " " "		5	12		225 " " " " east line of Tremont,		1	7	
Canton,	" " " "		3	31	1 ch.	250 " " " " " "		3	17	
Dedham,	30 feet from east line of Suffolk, towards Washington street,			26		250 " " west line of Tremont,				
						Suffolk towards Tremont,			11	
Chelsea,						223 feet from west line of Suffolk,				
Weston,						313 " " " "				
Waltham,			1			Intersection of Suffolk street,		1		

Hanson, - -					4			172 feet from west line of Suffolk street, -		4	
Lowell, - -					5			218 " east line of Tremont street, -		5	
Groton, - -					4			Below 12 feet above M. and W., - - -		4	
Dover, - -				10	64			Intersection of Suffolk street, - - -		60	
Garland, - -	197 feet from east side of Suffolk street, - - -				9	3		77 feet from east side of Suffolk street, - -		4	
Carney Place,	187 " " " " " - - -				2	8		155 " " " " " " - -		2	5
Lucas Place,	240 " " " " " - - -					5		155 " " " " " " - -			2
Cheney, - -	250 " " " " " - - -				12			115 " " " " " " - -		6	
West Castle,	150 " west line of Washington street, - -				10	12		315 " west line of Washington street,		10	12
	150 " south line of Castle street, - -							250 " south line of Castle street, -			
	124 " " " Pleasant street, - -							309 " " of Pleasant street, -			
Tremont, - -	600 " " " " " " - -				54	1		524 " " of " " -		28	
	Intersection of Camden street, between Worcester and Springfield, - - - - - -							Intersection of Pembroke street, - - -			
								" of Concord street, - - -			
Suffolk, - -	Intersection of Pembroke street, - - - -			5	62	42	2 ch.	" of Waltham and of Dover, - -		15	25
Albion, - -					13	5		Corner of Castle, east side, 11,479, - -		13	5
Village, - -					16			Below high water mark, - - - -		16	
Emerald, - -					22	10		" " " - - - - -		22	10
Middlesex, -					23	13		" " " - - - - -		23	13
Orange, - -	173 feet from west line of Washington street, - -				27	27		302 feet from west line of Washington street,		16	
Indiana Place,	305 " " " " " - -				6		1 ch.	508 " " " " "		1	
Ohio Place, -	265 " " " " " - -										
Osborn Place,	137 feet south of south line of Pleasant street, - -				10			315 feet from south line of Pleasant street, -			
Claflin Place,	136 " " " " " " - -										
Wheeler's Ct.,	121 " " " " " " - -				17	6		200 " " " " " -		13	2
London St.,	151 " " " " " " - -				32			270 " " " " " -		16	
Porter, - -	124 " " " " " " - -				38			358 " " " " " -		17	
Jefferson, - -	40 feet from east line of Fayette, towards Tremont,				4						
Bay, - - -	40 " " " " " "				2	8		Below high water line, - - - - -		2	8
Lincoln Ct. -	40 " " " " " "							" " " - - - - -			
Fayette, - -	10 feet from north line of Jefferson, towards Pleasant,				43			40 feet from south line of Jefferson, towards basin, - - - - - - -		40	14

Names of Streets.	Contour line, or Curve of 15 feet above mean low water.	Houses below 15 feet curve.				Contour line, or Curve of 12 feet above mean low water.	Houses below 12 feet curve.			
		Brick, 1st quality.	Brick, 2d quality.	Wooden Houses.	Public Buildings.		Brick, 1st quality.	Brick, 2d quality.	Wooden Houses.	Public Buildings.
Knox, - - -	10 feet from north line of Jefferson street, towards Pleasant, - - - - - - - - -			10		Below high water level, - - - - -			10	
Marion, - -	178 feet from north line of Church street, towards Pleasant, - - - - - - - - -		54			72 feet from north line of Pleasant, towards Church street, - - - - - - -		44		
South Cedar,	135 feet from south line of Pleasant street, towards Church, - - - - - - - - -		32			196 feet from south line of Pleasant street, towards Church, - - - - - - -		26		
Church, - -			19	9	1 ch.	East intersection of Providence, - - -		19	9	1
Piedmont, -	111 feet from south line of Pleasant street, - -		26	4		139 feet from south line of Pleasant street, -		20	4	
Shawmut, -	107 " " " " " " - -		13		1 ch.	162 " " " " " -				
Providence, -	200 " Pleasant street, towards Church, -		5			180 " south line of Church street, towards Basin, - - - - - - -				
W. Boylston,	144 " north line of Church street, towards Pleasant street, - - - - - - - - -	20								
		35	639	250	6			431	154	1

A. A.

Extracts from testimony of T. S. Smith, Esq., before the Commissioners of Inquiry "into the state of large towns and populous districts, June 15," 1843.

You say that fever is the disease to which the poorer classes are peculiarly subject, as arising from the filthy state of the districts and the wretched condition of the dwellings in which they reside; but is fever the only disease produced by these causes?

I particularize fever, because fever is the most obvious and the most rapidly fatal of the diseases arising from the neglect of sewerage ventilation, and cleanliness; but it would be a very inadequate view of the pernicious agency of the poison unceasingly generated in these filthy and neglected districts, to restrict it to the disease the most obviously produced by it. Its indirect action is highly noxious, though the evil is not so manifest. It is a matter of constant observation, that even when not present in sufficient intensity to produce fever, by disturbing the function of some organ, or some set of organs, and thereby weakening the general system, this poison acts as a powerful predisposing cause of some of the most common and fatal maladies to which the human body is subject. For example, the deaths occasioned in this country by diseases of the digestive organs, by inflammation of the air-passages and lungs, and by consumption, form by far the largest proportion of the annual mortality. Now no one who lives long in or near a malarian district is ever for a single hour free from some disease of the digestive organs. But disordered states of the digestive organs not only constitute in themselves highly painful and even fatal maladies, but they lay the foundation of several other mortal diseases. By a disordered state of the digestive organs, for example, the body is often so much enfeebled that it is wholly incapable of resisting the frequent and sudden changes of temperature to which this climate is subject—the consequence is that the person thus enfeebled perishes by inflammation set up in some vital organ, and, more especially, in the air-passages and lungs, or by consumption, the consequence of that inflammation; so that to the total number of deaths that take place annually from fever in its different forms, must be added those caused by the indirect operation of the same poison that produces fever.

* * * * * * *

So that those who live in such situations, even when they are not positively attacked by acute disease, are nevertheless undergoing a process of deterioration?

That is universally and strikingly indicated in two ways. First by the incapacity of the mothers to attend to their children; and secondly, by the bad health of the children, and their great mortality. It has already been shown by the experience of the Fever Hospital that the mothers are more susceptible of fevers than the husbands; but, when not laboring under acute disease, the mothers are often so enfeebled as to be unable to attend properly to their domestic duties, so that the children are not taken due care of, while the sickness of the children becomes an enormous tax on the time and wages of the parents.

* * * * * * *

Do you think the moral character and energy for the purposes of exertion, and employment of those persons, is very much lessened in consequence of their suffering, both from fever and the other diseases you have mentioned, and the continual neglect in which they appear to live?

The poison generated in these neglected districts, and to which these poor persons are habitually exposed, is a sedative poison, among the most distinctive characters of which are the depressing effects produced by it both on body and mind. This is one of the main causes, not only of the mental apathy, of which I have already spoken, but also of that physical listlessness which makes them incapable of any great exertion. I am satisfied that this feeling of depression is one of their chief inducements to the use of stimulants, which the same feeling naturally leads them to take in excess, whenever a sufficient quantity can be procured. I quite believe, from what I have observed of them, that the inducement to take the most pernicious amount of stimulants often arises from a sensation of languor and lassitude, the direct result of the debilitating causes that are incessantly acting upon them, and that renders them so incapable of physical and mental exertion.

Every one who has observed his own sensations during the few days which precede an acute attack of fever, can well appreciate that feeling of *malaise*, more intolerable than pain; and it is no wonder they fly to anything which affords a prospect of temporary relief from it.

B.

Quantity of rain falling at certain times suddenly, and above the average of rain storms; as observed at Cambridge, Mass., by G. P. Bond, Esq.

1841,—June,	in about	3	hours,	3.50	inches,	or 1.16	in.	per	hour.
1840,—July 23,	"	3	"	1.50	"	0.50	"	"	"
1848,—Aug. 18,	"	2½	"	0.70	"	0.28	"	"	"
" Sept. 1,	"	1½	"	2.81	"	1.87	"	"	"
1849,—Nov. 19,	"	6	"	3.336	"	0.556	"	"	"
" Dec. 22,	"	7	"	1.919	"	0.275	"	"	"

Similar Observations in Boston, by Jonathan P. Hall, Esq.

1823,—July 16th. There fell in 10 minutes, 1½ in. of rain.

1824,—September 5th. There fell in showers during the night, 2.19 in.

1829,—July 30th. A succession of very heavy thunder showers, each lasting 20 to 30 minutes; probably at each shower an inch of rain fell; in all, 5 inches.

1835,—July 15th. A succession of very heavy thunder showers, filling the cellars in Elm Street, Union Street, Market and Dock Squares, &c. &c.; each shower lasting 20 to 30 minutes. Probably about an inch of rain fell in each shower. The total quantity was 5.38 inches.

1845,—November 27th. Rain commenced at 8 A. M. and ceased at 4 P. M., in which time there fell 3.35 inches.

There is no doubt that occasionally, in summer, an inch of rain will fall in 15 or 20 minutes.

C.

From Testimony of Mr. J. Phillips, before the Metropolitan Sanitary Commissioners.

Have you at all considered the capacities of sewers, necessary for draining different areas of ground?

Yes, I have given the subject much attention. If the consideration of the sizes of sewers was confined solely to the carrying off the water supplied by the several water companies, then, I apprehend, that pipes, somewhat larger in size than the supply pipes themselves, would suffice; but provision has to be made for receiving and carrying away the waters of heavy rains. In London, continuous heavy falls of rain are not of long duration, lasting seldom more than from one to four hours. About one-fifth of the quantity that falls is absorbed, partly by the dryness of the surface of the roofs, the paving, and the ground, and partly by the porosity of the ground itself.

A farther proportion is also prevented from flowing to the drains and sewers at all, by hollows in the surface; and again reascends into the atmosphere, as vapor. There is also a small quantity that enters into the composition of animal and vegetable bodies. Then, there is the resistance which the flow experiences, from the friction of the entire surface being accelerated or detained, in proportion as the surface is more or less inclined. To provide for the discharge of a fall of rain of two inches in depth, has been considered, by Mr. Hawksley, C. E., the extreme datum upon which to proportion the capacities of town sewers generally. Now I believe that, practically, the sizes in his table, although they may appear theoretically correct, are (excepting for the smallest sizes) too large for sewers in London. It is extremely violent rains alone that produce a depth of two inches per hour, and such rains occur only once in four or five years, if so much. I am of opinion, that it is unnecessary to proportion the size of the sewers, to meet an extraordinary occurrence that may probably happen only once in so many years. My reason for not fearing any serious damage from an excess of rain, at remote intervals, being provided for in surface channels, excepting, perhaps, in situations peculiarly liable to inundation, (for instance at the foot of a long or steep declivity, or where the waters may, from any cause, be suddenly congregated at one focus) is, that I have observed, that in towns entirely destitute of underground drains, no such inconvenience is felt as would justify the formation of enormously large sewers, or the expenditure of large sums of money to provide against it. In August, 1846, a most extraordinary fall of rain occurred in London. The storm lasted nearly two hours, and from the best information I have been able to obtain, the depth of rain amounted to about four inches. Much damage resulted therefrom, by the water in the principal main lines, situate in the valleys, flowing up the drains and branch sewers, and inundating the rooms and cellars below its level by the influence of its pressure.

C. C.

An approximate Estimate of Filling, requisite to bring the following named Streets to the level of high water mark.

Concord Street,	11,500	cubic	feet.	
Rutland "	15,000	"	"	
Newton "	49,800	"	"	
Pembroke "	44,100	"	"	
Brookline, "	49,000	"	"	
Chelsea, "	87,500	"	"	
Weston "	112,750	"	"	
Waltham "	109,500	"	"	
Hanson "	38,480	"	"	
Milford "	86,000	"	"	
Groton "	83,600	"	"	
	687,230	"	"	=25,453 cubic yards.
Add for four Streets, of which profiles have not been taken, viz: Northampton, Chester, Canton and Dedham, estimated at - - - - -				9,256
				34,709
Tremont Street, from Camden to Dover,				31,484
			Total,	66,193 cubic yards.

Which, at 30 cts. a cubic yard, would cost $19,857 90.

D.

From testimony of D. Williams, Esq., C. E., before "the Commissioners of Inquiry into the state of large towns, &c.," March 21, 1844.

If proper science were available, would there be any question as to the shape (*of sewers,*) in respect to strength?

I believe not. I am aware that there are certain physical questions which have been investigated scientifically, and, about the results of which investigations, much difference of opinion still prevails. But a well known theory of the equilibrium of sustaining walls for earth, is universally accepted as true, and is confirmed to be such by its repeated application in hydraulic works, and frequent adoption for culverts, retaining walls, &c. The theory, the investigations of which were first pursued by Coulomb, indicates that a sewer, with an external convex form, to resist lateral pressure, is the most stable. With firm ground, the egg-shaped sewer would be the best. For known conditions of varying densities in the external earth, modifications from the egg shape would be required; but, in no case, departing from the application of the principle of the arch. With semi-fluid ground, it should approach more nearly to the form of the circle. The egg-shape, however, presents this important advantage for the conveyance of water, exclusive of its superior strength and economy, that when the water is small in amount, the narrowness of the lower part gives a greater hydraulic depth, and therefore produces increased velocity; and when the body of water is increased, more capacity is obtained. The superiority of the egg-shaped sewer, in point of strength, is so self-evident, that it really appears a work of supererogation to demonstrate it technically. All grant that the properties of the arch are such as to resist pressure with the least consumption of materials; and, that the outward batter, or slope, is useful to resist the lateral, or inward pressure of the external earth, is an admitted principle, acted upon instinctively by every one. Whoever walks against a strong wind instinctively leans forward against it, being well aware that, with the body in a reclining or sloping direction, he can resist its force better than if he stood upright.

E.

From testimony of Wm. Hosking, Esq., before "the Commissioners of Inquiry into the state of large Towns, &c.;" June 10, 1843.

Have you considered the question of damp rising in low situations upon the walls of the houses, thereby injuring the health of the inhabitants?

I have, and am prepared to advise strongly that there should be a legislative provision, that the foundations of every house should be drained; that is, that the lowest level of the foundation should have a vent for the water. If the water were drained from the lowest level, the walls need not be affected by damp at all.

* * * * * * *

Have you turned your mind to the practicability of improving the healthiness of inconveniently low situations in or near London; such, for instance, as that part of Westminster between Tothill Street and the Horseferry road? I have; and I believe that the soil drainage of that district may be made perfectly efficient, and a very proper and satisfactory backwater obtained from the river, to scour its sewerage into the river. The tide rises and falls in the Thames at London, at ordinary spring tides, about 18 feet, and at neap tides about 15 feet. Now, if the outfall of a common sewer be about three feet above low water at neap tides, it will be high enough to allow the escape of everything that can have to pass through the sewer. I have found from experience, that sewers, moderately well supplied with backwater, may be made with much less fall than is generally considered necessary, and less than this bill requires. I myself directed the diversion of one of the large sewers at the western extremity of London, the Countess' Creek Sewer, for a mile and a half of its length; and for the purpose of obtaining deeper drainage at the upper end, I prevailed upon the Commissioners to allow the fall to be at the slight rate of 1.63 inch,—less than $1\frac{3}{4}$ inch,—in 100 feet, throughout the diverted length; the sewer being the course of a small stream, the drainage of the uplands. With this small stream, the sewer with its slight fall, is kept perfectly clean; no accumulations of any kind take place in it; and I think I may assume, therefore, that a fall of 2 inches in 100 feet, with a good backwater at frequent intervals, would be sufficient.

From testimony of Mr. James Beck, before the same, June 19th, 1843.

Are your drains made on a particular fall?

Where I could get the fall, I like it about a quarter of an inch to 10 feet; I think that is desirable; but there are sewers where we have only the eighth of an inch fall.

Have you found that they keep themselves clear?

Yes; they act exceedingly well.

Is that the least fall you have known?

A.

RELATIVE POSITION TO TIDE WATER, OF STREETS AND HOUSES, ADJOINING THE BACK BAY.

Names of Streets.	Contour line, or Curve of 15 feet above mean low water.	Houses below 15 feet curve.				Contour line, or Curve of 12 feet above mean low water.	Houses below 12 foot curve.			
		Brick, 1st quality.	Brick, 2d quality.	Wooden Houses.	Public Buildings.		Brick, 1st quality.	Brick, 2d quality.	Wooden Houses.	Public Buildings.
Arnold,	350 feet from W. line of Washington st.			5						
Lenox,	170 feet from W. line of Suffolk, towards Tremont,									
Camden,	Intersection of Tremont street, and 50 feet from west line of Suffolk street,									
Northampton,	15 feet from west line of Suffolk street,			2						
Chester,	50 " " " "									
Springfield,	At intersection of Suffolk st., 353 feet above,									
Worcester,	382 feet from east line of Tremont,									
Concord,	360 " " "					35 feet from east line of Tremont, and at intersection of Tremont,				
Rutland,	275 " " "					100 feet from east line of Tremont street,				
Newton,	Intersection of Newland street,		2	1		185 " " " " " "				
Pembroke,	Intersection of Suffolk street,			13		155 " " " " and intersection of do.				
Brookline,	" " " "		5	12		225 " " " " east line of Tremont,		1	7	
Canton,	" " " "		3	31	1 ch.	250 " " " " " "		3	17	
Dedham,	30 feet from east line of Suffolk, towards Washington street,			26		250 " " west line of Tremont,				
						Suffolk towards Tremont,			11	
Chelsea,						223 feet from west line of Suffolk,				
Weston,						313 " " " "				
Waltham,			1			Intersection of Suffolk street,		1		

F.

From testimony of Wm. Hosking, Esq., before "the Commissioners of Inquiry into the state of large Towns, &c."—June 10th, 1843.

Supposing heavy rains should occur at the period when the tide is up, how do you provide for the escape of the water through those drains?

You cannot be protected with certainty against that contingency, except by pumping, wherever the land is below the high tide or flood level; but the sewers may be made, in the case supposed, of sufficient capacity to retain all the water that could accrue between tide and tide, except under extraordinary circumstances. In connexion with the operation I have spoken of, I found it necessary to provide for the relief of some six or eight acres of land at a level very considerably below high tide, in fact not more than from four to six feet above the level of the low tide. I provided a drain that I calculated to be large enough to hold all the water that would fall between low tide and low tide upon the extent of surface to be relieved; and from frequent observation, I believe the provision made was sufficient to prevent any overflow.

How long has that been in operation?

Three or four years. I provide for stopping out the tide by flapping the mouths of the sewers, and as these flaps are self-acting, the sewers empty themselves without assistance, and, when the tide flows, the flaps are pressed close up by the tidal water, and the sewers are free to receive the water that may accrue upon the surface from rain or snow. Their capacity may, however, be insufficient, and the district may be flooded before the ebb takes place; a difficulty that cannot be wholly provided for without pumping. To avoid such contingency for the future, I think there should be a legislative enactment to prohibit the building of houses below the level at which they can be efficiently drained and protected from flood waters by the ordinary means of drainage.

F. F.

From testimony of Mr. J. Phillips, before "the Metropolitan Sanitary Commissioners."

It must, however, be admitted, that the method of flushing the sewers is only an expedient to be resorted to when the sewers cannot be kept clean by the simple means of proper construction and efficient fall; I would, therefore, beg to suggest another distinct method of proceeding, which, in the end, will prevent the matter discharged into the sewers from becoming deposited upon their channels. I propose that all the secondary or collateral sewers, those which branch out of the main lines, as also those which communicate with, and discharge their contents into, these secondary lines, should be strictly examined and properly surveyed; the relative levels throughout each of these collateral districts should also be carefully taken and laid down, with a view to an improvement of their falls.

From testimony of T. L. Donaldson, Esq., before "the Commissioners of Inquiry into the state of large Towns, &c.," July 10, 1843.

If a sufficient supply of water, from whatever source derived, would cleanse those sewers, you would say that that would be very desirable?

Certainly. It would depend upon the expense of procuring the water.

Do you think that that body of water would carry away not only the soil, but also the scrapings of the roads?

I am not prepared to say that it would; but I think the usual showers in the streets will do that.

How are your flaps constructed; have they the power of shutting back the water from the river?

They are simple iron flaps, hung so as to keep shut while the water was not passing out.

Might not a dog's head, or some obstruction, prevent their being closed?

Sometimes even a slighter obstruction may prevent it.

And then the water enters? Yes.

Do you not consider that that flap is susceptible of great improvement?

We have directed our attention to it, and shall be happy to see any improvement adopted.

Is there any register kept as to the state of the tide and the influence of certain heights of the water? Yes.

Are there not districts in which there are arrangements made for putting down valves as the water rises, and lifting them as it falls?

No; we have nothing but these flaps.

Do you think it would be safe to trust to those flaps in places where it might be an object of great importance that the water should never, by any chance, enter?

We have no other means of doing it: we use double flaps occasionally.

G.

From testimony of Mr. J. Phillips, before "the Metropolitan Sanitary Commissioners."

It should be distinctly understood that no more work should be commenced until the sizes and falls of all the sewers have been determined on, and rearranged according to a regularly graduated scale, and I have no hesitation in saying, that until either this be set about and done, or they be entirely rebuilt, there are very many lines which will never be any other than elongated and filthy reservoirs or cesspools, the matter in which will be continually contaminating the atmosphere with its deleterious products.

These great evils require immediate reparation, which should not be done piecemeal, but upon a well organized system of arrangement; and if the matter be taken up, as I trust it will, the cost of putting the whole of the badly formed sewers into a state of comparative efficiency could be ascertained without great difficulty.

* * * * * * *

Are you satisfied that in your new arrangements of the sewers and the levels you determine to put them in at, you are designing the work correctly, and with a view to their future extension, and for the improvement of other districts?

No; I cannot say that I am quite satisfied of that. All piecemeal work, however careful one may be, is liable to lead to disappointment.

When I begin the work of improvement in a street, I am induced, with a view to a complete arrangement of the sewers, to travel from that street to another, and so to another, until I go so far as to embrace an entire district, and even then I find it necessary to take in other districts as well. I know not where to stop, the drainage and the sewers generally being so very bad and dilapidated, and nearly the whole, in some way or another, requiring alteration or amendment. I often find it necessary to take up sewers that have been put in of late years. I do so rather than risk incompleteness. I should feel more safe and confident, in being able to produce a perfect arrangement of the sewers, had I to lay down an entirely new and complete scheme for the improvement of the drainage of the whole of a natural area, or of the entire metropolis, than I should do by simply taking a small section of either; and my experience in the laying down of plans for the re-arrangement and improvement of the sewers obliges me to say, that the drainage will never be improved as it should be until a comprehensive scheme is put in hand, similar to what I have described.

How would you proceed to lay out the drainage of an undrained town district?

In the first place I would make a correct plan of that district, and then take the levels and contour of the plan. After this was done, I should, commencing at the outlets, proceed to lay down on the plan the arrangement of the lines of sewers, so that they should all communicate with each other upon a uniform system of levels, and in the manner I have before described.

Having determined their arrangement, the next step would be to make complete working sections of all the sewers, showing their depths and inclinations with reference to a fixed datum line.

The capacities and thicknesses I would then regulate (after providing for their extension to other districts, and for carrying off the backwaters of the natural area) progressively from their heads to their outfalls, and according to the number of houses, quantity of water, and area to be drained by each sewer, allowing them to be of sufficient capacity for receiving and conveying away rain and storm waters.

H.

From testimony of T. S. Smith, Esq., M. D., before "the Commissioners of Inquiry into the state of large Towns, &c.," June 15th, 1843.

Have you paid any attention to the value of refuse matter considered as manure, and to the practicability of so ordering things, as to make this manure repay in some degree the cost of removal?

Yes, I have been very much struck with the evidence that has been collected on this subject, which appears to me to be so important as to deserve the most serious attention. I own that I have been unable to detect any fallacy in it, and I cannot but regard it as affording a well-grounded hope that the means of putting every town and village in the kingdom in a good sanitary state, and of removing the grievous physical evils which at present oppress them, and especially the poorer parts of them, are within our reach. When, for example, it is stated, that refuse to the value of nearly double of what is now paid for the water of the metropolis is thrown away, partly from the drains which are sewered into the Thames, and partly from the private drains which are not sewered at all; it is clear that the prevention of the disease, suffering and death, which, it has been shown, oppress such large classes of our population, is quite practicable; and that if measures are not taken to stop these dreadful evils, it is not owing to any insuperable difficulty, but to our own apathy and indifference.

You think, under proper regulations, it would be found practicable to make the very refuse go far towards defraying the expense of constructing and managing the drains and sewers by which it is removed?

Yes; and I think there is a reason for this expectation, which has a deeper foundation than is apparent on a superficial view of the subject. There are certain adjustments established between the physical and the organic kingdoms, and between the two great divisions of the organic kingdom, which we should do well to bear in mind, even in the most practical consideration of this matter. We know that atmospheric air is equally necessary to the life of plants and animals, but that they produce directly opposite changes in the chemical constitution of the air; the plant giving off, as excrementitious, that principle of the air on which the animal subsists, and living on that part of it which the animal rejects as excrementitious; while the

animal, in its turn, restores to the air the principle which constitutes the food of the plant, and subsists on that which the plant has rejected as no longer useful to it. In this manner these two great classes of organized beings renovate the air for each other, and everlastingly maintain it in a state of purity and richness. On this beautiful adjustment depends this further principle, equally at the foundation of all rational and efficient sanitary regulations—namely, that the very refuse of the materials which have served as food and clothing to the inhabitants of the crowded city, and which, if allowed to accumulate there, invariably and inevitably taint the air, and render it pestilential—promptly removed and spread out on the surface of the surrounding country, not only give it healthfulness, but clothe it with verdure, and endue it with inexhaustible fertility. These are great laws of nature, which are now well known to us; a due conformity with which would bring us pleasure, health, and plenty, but which we cannot disregard any more than we can disregard any other physical law, without suffering, and perhaps destruction. Do we act in conformity with these laws? I turn to the report on the Sanitary Condition of the Laboring Population, and I find the following account of the actual state of things:—"Within the towns we find the houses and streets filthy, and the air fœtid; disease, typhus, and other epidemics rife amongst the population; bringing in the train destitution, and the need of pecuniary as well as medical relief; all mainly arising from the presence of the richest materials of production, the complete absence of which would in a great measure restore health, avert the recurrence of disease, and, if properly applied, would promote abundance, cheapen food, and increase the demand for beneficial labor. Outside the afflicted districts, and at a short distance from them, as in the adjacent rural districts, we find the aspect of the country poor and thinly clad with vegetation, except rushes and plants favored by a superabundance of moisture, the crops meagre, the laboring agricultural population few, and afflicted with rheumatism and other maladies, arising from damp and an excess of water; which, if removed, would relieve them from a cause of disease, the land from an impediment to production, and, if conveyed for the use of the town population, would give that population the element of which they stand in peculiar need as a means to relieve them from that which is their own cause of depression, and return it for use on the land as a means of the highest fertility. The fact of the existence of these evils, and that they are removable, is not more certain than that their removal would be attended by reductions of existing

burdens, and might be rendered productive of general advantage, if due means, guided by science, and applied by properly qualified officers, be resorted to." If there be any truth in these statements it is surely worth while to consider how far it may be practicable to lessen the present heavy expense of drainage, and what means are at our command of turning the refuse matters to account, so as partly, at least, to defray the necessary cost of drainage.

From testimony of E. Cresey, Esq., before "the Commissioners of Inquiry, &c.," June 24, 1843.

Has it occurred to you whether in such a town as that, (*Dartford,*) it would be possible not only to drain the suburbs more effectually, but occasionally to turn the refuse to account?

In large cities or towns it might be turned to very great account. If the contents of all the sewers could be brought to a convenient situation for disposal, it would sell for a very considerable sum, and amply repay the cost of any means that might be used to bring it there.

What is paid for the manure there?

We give now about £10 a barge load, which contains about 40 tons, then we have to cart it away.

What is the cost of carting it from the barge?

It depends upon the distance we have to cart it. When I had it at Horton Kirby, we could not go more than twice or three times a day. With respect to the flushing system, there would be facilities for applying the refuse to irrigation. If you adopt the flushing system, you would probably have two reservoirs; one would contain the liquid and the other the solid. I would adopt the principle which is acted upon in Paris. They have two tubs, one to contain the matter that comes from the water-closets, and as the liquid rises it goes into another tub, and then they take that away, and they have in the other tub the solid matter. If you have two reservoirs formed upon that principle, I think you will manage with the flushing system very well.

You would dispose of the fluid by irrigating the meadows in the neighborhood?

Yes; all the paper and other light refuse floating upon it would be convertible to useful purposes.

From testimony of Mr. Thomas Cubitt, before "the Commissioners of Inquiry, &c.," June 8th, 1843.

Do you consider it an objectionable thing in itself that so much material should be swept into the river uselessly, if it could be avoided?

With respect to sewerage, it appears to me that the whole material, we may say, that is consumed in London is all swept away, or nearly so, by the river, and that there must be quantity enough every week swept away to fertilize a vast number of acres of land if made productive; but I do not think that the present state of our knowledge will enable us to use it with economy, or that we can lay down any plan at present for collecting it, although I should like to see it taken away from the towns as fast as possible. I regret very much that we should carry our drainage into the part of the Thames we do; I regret that something is not done to enable us to carry the foul matter all away from London.

You would be glad to see any practicable method by which the refuse of the town should be carried into the country?

I should; and I think the best way of furnishing the means of that, would be to carry it further off from the town, and not into the upper part of the river, but to carry it further before the discharge mixes with the river.

You have not considered any of the plans which have been spoken of for carrying away the impurities of water to a distance, so as to fertilize the districts in the neighborhoods of populous cities?

I have thought a great deal about them, but I am not aware of any plan which could be worked out so as to make it economical.

If it could be removed consistently with economy, you would consider that a great object was attained?

Certainly.

Extract from the "Second Report of the Commissioners of Inquiry into the state of large Towns and populous Districts." 1845.

"As the subjects specified in your Majesty's Commission are essentially of a practical character, we have endeavored to avoid as far as possible the discussion of the theoretical causes of disease. All the medical witnesses examined before us are unanimous as to the injurious effects produced by emanations from animal or vegetable matter in a state of decay, whether they act as direct or contingent causes of disease; and they are quite concurrent in their opinion that the existence of such causes and their prevalence have been sufficiently ascertained to require the interference of the legislature. The presence of such emanations, whether they be derived from stagnant ditches, from open cesspools, or from accumulations of decaying refuse, is a great cause of disease and death, not confined to the immediate district in which they occur, but extending their influence to neighboring, and even to distant places.

These physical causes of disease may affect various localities and different classes of persons, but are most common and virulent in the neglected districts and dwellings of the poor, who are peculiarly exposed to the aggravating influences of such causes,—not necessarily connected with their condition in life, but capable of being removed by efficient drainage, cleansing, improvements of buildings, ventilation, and a sufficient supply of good water.

It is too commonly supposed that the evils above adverted to are the inseparable concomitants of poverty; and, doubtless, so long as the inhabitants of the most neglected and filthy abodes in crowded cities are unable to provide for themselves better and healthier dwellings, sufficient light and air, more open situations, effective cleansing and drainage, and adequate supplies of water, their vigor and health are undermined, and their lives shortened by the deleterious external influences consequent upon the want of efficient arrangements for securing the above objects. The operations of general sanatory arrangements, will enable a greater number to contribute a share to such arrangements by which they must largely benefit, and thereby and at a comparatively small cost to the community at large, to have the advantage of the remedial improvements above specified.

Without entering into any discussion upon the influence which poverty and distress may occasion on the rates of mortality, which no sanatory improvements can entirely prevent, we are desirous to remove the injurious impression that a great amount of excessive disease and death in this country is due to causes, which cannot in a considerable degree be removed by legislative enactments when earnestly enforced. At the same time we must express our opinion that the efficient execution of the law will tend to reduce sickness and disease, and so far increase the means of the poor.

Medical witnesses of much experience state that the continued action of injurious emanations, though they may not always produce fever, often become the cause of some of the most common and fatal maladies of this country, and the residence more or less prolonged in a vitiated atmosphere is a great cause of the *scrofulous diseases*, extensively prevalent in the large towns.

In an inquiry into the influence of employments on health, it appears that the relative excess of deaths from consumption among tradesmen and artisans, compared with other classes, is mainly to be attributed to the vitiated state of the atmosphere in their shops and dwellings. The average age at death from consumption has been found to be lower in the case of tradesmen than among artisans; this is stated to be owing to a larger proportion of the latter being employed in out-door work, and therefore less continually exposed to the influence of an impure air.

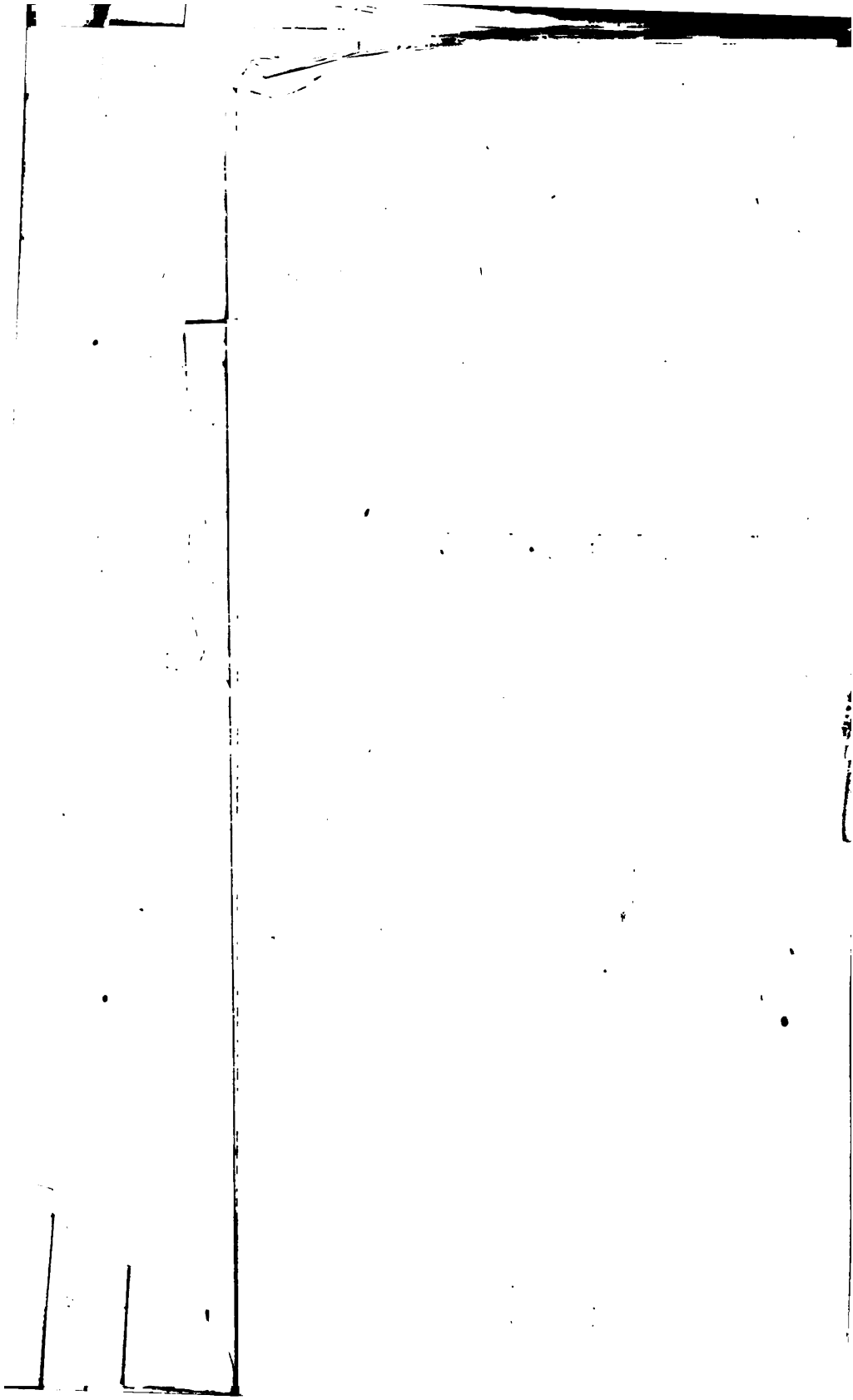
In addition to the evils arising from the absence of ventilation in the interior of dwellings, a great amount of disease is engendered by the polluted condition of the atmosphere in the close and confined courts in which a large proportion of the poor constantly dwell.

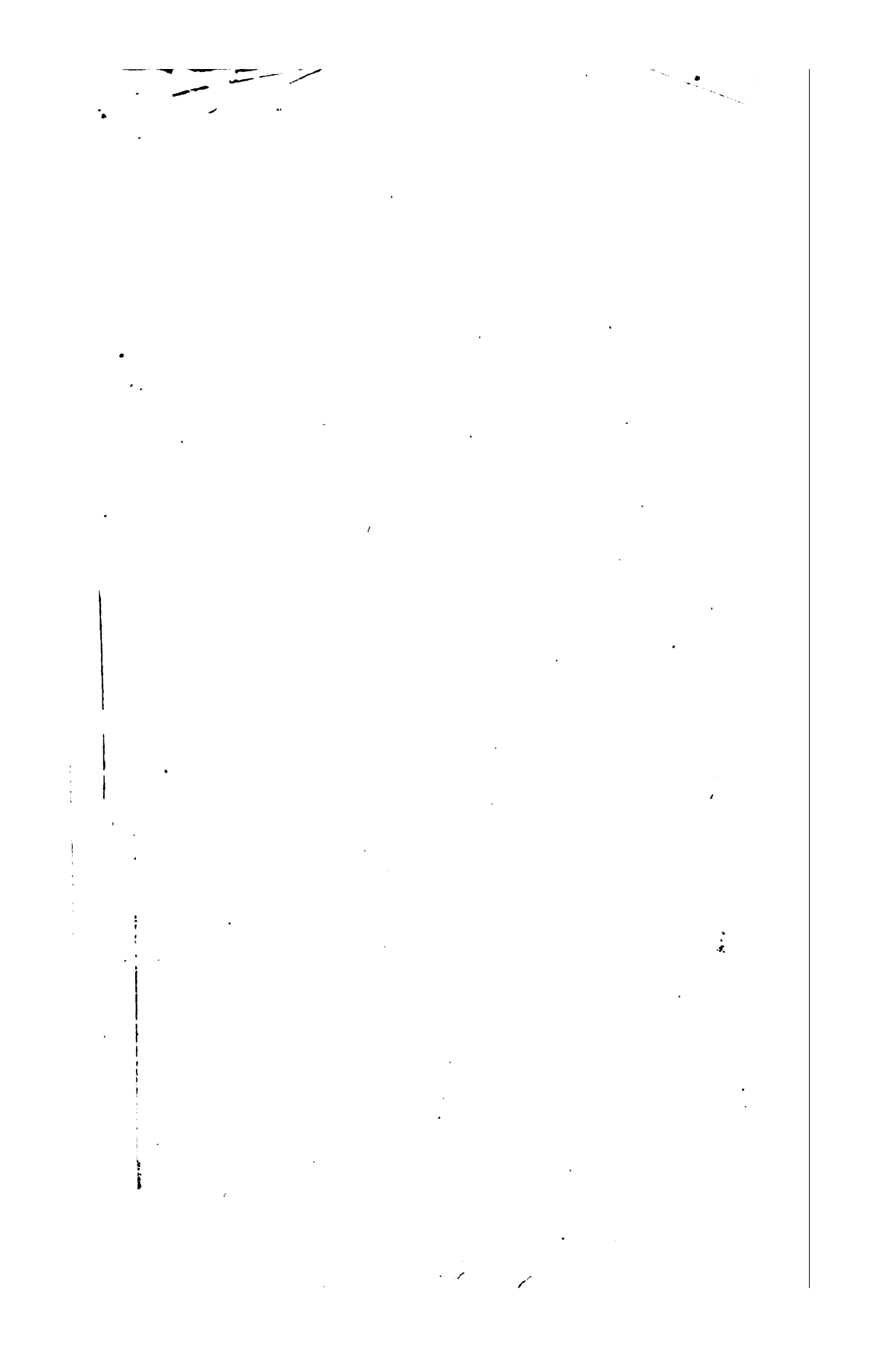
Our attention has been called to the consideration of the ages at which the physical causes of disease produce their most marked effect; and while the returns show that these effects are peculiarly severe on infantile life, yet they are not confined to any particular age, acting powerfully on persons in the full vigor of life, as well as on the younger part of the population. These returns all show that the extreme pressure of the physical causes of disease is upon the working population, shortening the average duration of life from one to twenty, and even to thirty years, and decreasing to a material extent the working ability of the survivors. We find, however, at the same time, that the duration of life of the middle and higher classes is materially lessened by the pressure of these removeable causes of disease. In the diseases which follow, in a more marked degree, from

the direct or indirect influence of injurious emanations, especially in the case of fevers of the typhoid type, by far the greater proportion of cases occur amongst the heads of families between the ages of twenty and thirty, the very period when they have generally the greatest number of young children dependent on them for support. The effect of the physical causes of disease is not confined to any class or age.

The inquiries into the state of districts before and after improvement have distinctly shown, that increased facilities for the removal of refuse in and about the habitations of the poor have been rapidly followed by a marked improvement in the health, and by a reduction in the rate of mortality of the district. An instance of this kind was observed in Manchester by ascertaining the amount of deaths in twenty streets before and after their improvement, by which it was ascertained that the deaths immediately subsequent to the drainage and paving of the streets were diminished more than 20 per annum out of every 110. This mode of exhibiting the immediate effects of structural improvement has been confirmed in other instances, and is cited in verification of the same results, obtained by estimating the mortality in improved and in unimproved districts of a like population.

The loss of life which occurs annually from a neglect of the measures necessary for rendering wholesome the dwellings of the poor and the streets adjacent, must be accompanied by serious pecuniary charges both upon the sufferers themselves and upon the community. The prolonged attacks of sickness which precede this excessive mortality, render the victims of it incapable of following their daily occupations, and reduce them and their families to the necessity of seeking relief from the parish and other funds, which are eventually burthened with the maintenance of the surviving members of the family."





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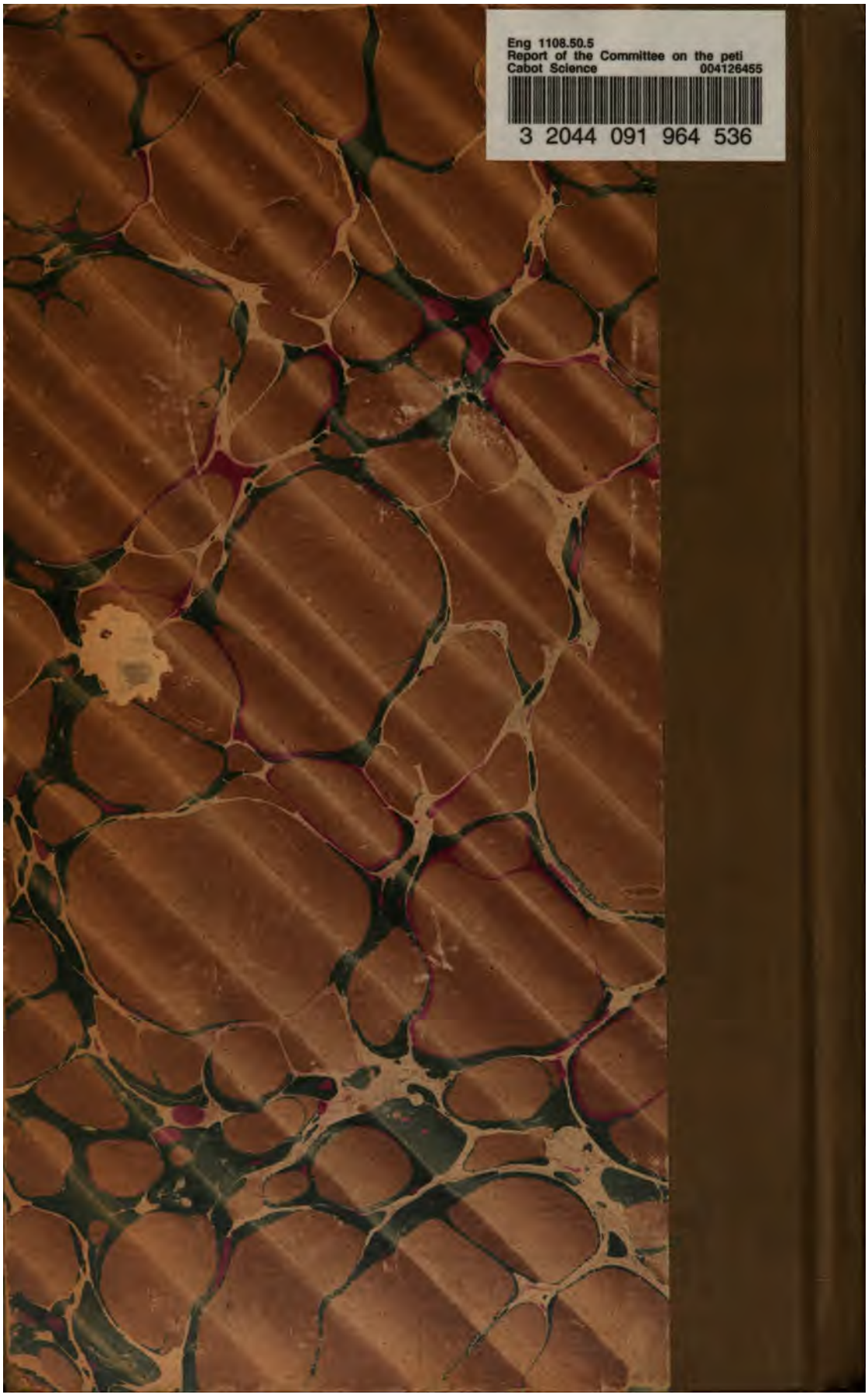
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